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PENSOFT

A ghost in the mist: extension of the known range of Colombian Weasel, *Neogale felipei* (Izor & de la Torre, 1978) (Carnivora, Mustelidae), in the Cordillera Occidental

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Abstract

The Colombian weasel, *Neogale felipei* (Izor & de la Torre, 1978), is one of the most enigmatic and threatened carnivores in South America, with only six confirmed records in the Andes of Ecuador and Colombia. During a long-term trail camera survey conducted at Mesenia-Paramillo Natural Reserve, we recorded the northernmost occurrence of the species, which extends its distribution by approximately 120 km to the north from the nearest previously known locality in Colombia. We also provide some comments on its natural history.

Keywords

Andes, *Mustela felipei*, mustelid, private reserve, rarity, trail camera, Western Cordillera

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Introduction

Highly mobile animals with elusive behaviors prominently contribute to the so-called Wallacean shortfall, where the distribution of species is deficient or poorly understood (Bini et al. 2006). The uncertainty of where species actually occur is of special concern in conservation planning, given the inherent difficulties in localizing threats and performing mitigation actions (Hortal et al. 2015). The Wallacean shortfall is scale-dependent; thus, by increasing the spatial grain in which species occur, we decrease our knowledge and accuracy on their realized distributions (Bini et al. 2006). Small mammals are vulnerable to habitat fragmentation and degradation, which

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together with the knowledge gaps in their geographic distribution and natural history, represent threats to their populations (Pereira et al. 2021).

The American weasels, genus *Neogale* Gray, 1865, which until recently were considered members of *Mustela* Linnaeus, 1758, comprise a clade of highly mobile carnivores with an extraordinary evolutionary history (Koepfli et al. 2008; Patterson et al. 2021). The four species of the genus are distributed across diverse habitat types, from the Arctic Circle to tropical rainforests, and have reached most latitudes in the Western Hemisphere (Burgin et al. 2020). From a biogeographical perspective, the distribution of most *Neogale* species is well defined (Patterson et al. 2021). For instance, Long-tailed Weasel, *Neogale frenata* (Lichtenstein, 1831), is the most widely distributed member of the genus, inhabiting from nearly intact forests to semi-urbanized areas (Harding and Dragoo 2012). In contrast, other species are rarer and more restricted to particular habitat types. For example, Amazonian Weasel, *Neogale africana* (Desmarest, 1818), is known only from Amazonian rainforest, and Colombian Weasel, *Neogale felipei* (Izor & de la Torre, 1978), is known only from the cloud forests of the northern Andes (Ramírez-Chaves and Patterson 2014; Ramírez-Chaves et al. 2014; de Roux et al. 2019). Indeed, *N. felipei* is the rarest carnivore in South America, with only seven validated records over an elevational range of 1525–2700 m (Ramírez-Chaves and Mantilla-Meluk 2009; de Roux et al. 2019). Globally, *N. felipei* is categorized as Vulnerable (González-Maya et al. 2016), although in Colombia, the species is listed as Endangered due to the restriction of its geographic range by the fragmentation of highland forests, which face pervasive transformation by agricultural activities (Mesa-González 2006). To date, there are only two records of *N. felipei* from the Cordillera Occidental (Western Cordillera) of Colombia: (1) Alto Galápagos, near the Chocó–Valle del Cauca border (Alberico 1994), and (2) Finca Morobia, Dagua, in Valle del Cauca (de Roux et al. 2019). Here, we present a range extension of *N. felipei* in the Cordillera Occidental of Colombia, based on data obtained through a long-term trail camera survey in a private nature reserve of the Department of Antioquia. We also provide preliminary evidence on the diurnal activity of this species, describe the habitat features of the locations where it was detected, and report additional evidence of its sympatric occurrence with the more eurytopic *N. frenata*.

Methods

From September 2018 to April 2021, we installed trail cameras in the Mesenia-Paramillo Natural Reserve (05° 29′43″N–05°27′34″N, 075°55′03″W–075°53′03″W; 1700–3167 m elev.), a protected area on the eastern slope of the Cordillera Occidental in the Department of Antioquia, Colombia (Fig. 1). We experimented with several

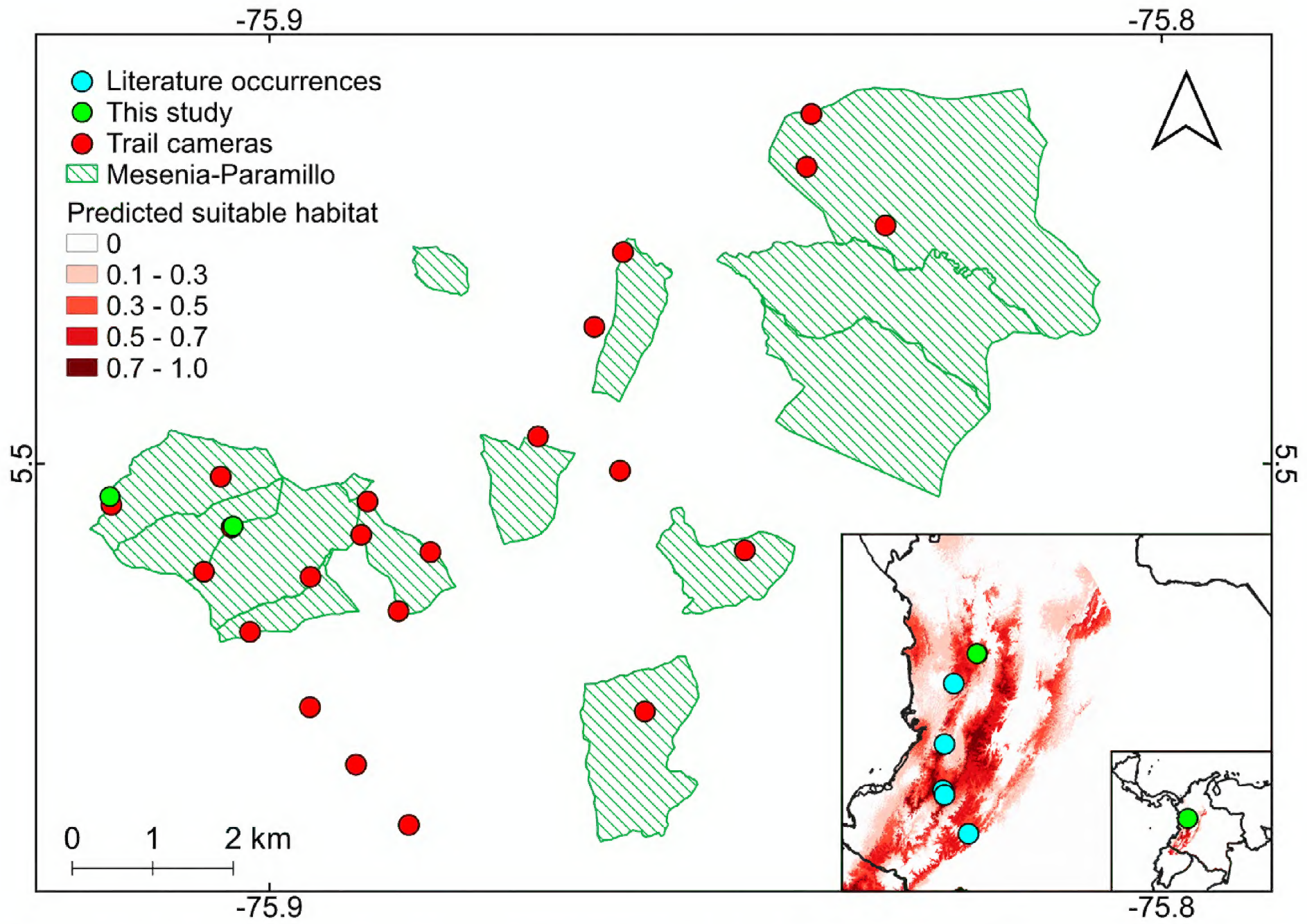

Figure 1. Location of the trail camera stations and *Neogale felipei* occurrences at the Mesenia-Paramillo Private Nature Reserve, Cordillera Occidental, Colombia. The predicted range of the species is derived from de Roux et al. (2019).

camera brands (Reconyx, Bushnell, Blaze Video, Victure, Apeman, and Browning) which were separated at a linear distance ≥1 km among cloud forest patches that were interspersed in a matrix of crops, cattle ranches, and logging plantations (Amézquita et al. 2013). Cameras were tied to trunks at 30–40 cm above the ground at sites with signs of wildlife presence. Locations of the cameras were georeferenced with a Garmin GPSMap 64s GPS receiver.

We set the cameras to take a sequence of three videos and photos at 5 s intervals and with a high motion-detection sensor. We also described the habitat structure of each camera site, following the Freitas et al. (2002) protocol in a 5 × 5 m plot with the camera as the centroid (Lombardi et al. 2020). We measured canopy height with a Nikon Prostaff Rangefinder, and litter depth by inserting a sharp knife into the leaf litter until it reached the soil, then marking the knife blade and measuring the blade with a measuring tape (Alves et al. 2017). We estimated the site's slope with a Suunto Clinometer. All the sightings of *N. felipei* occurred during daylight, which allowed us to identify the diagnostic external traits described for the species, such as the presence of a short tail lacking a black tip (Ramirez-Chaves and Mantilla-Meluk 2009; Ramírez-Chaves and Patterson 2014) and by direct comparisons in the field with our own photographs of *Neogale frenata* (Fig. 2C, 2D). We shared videos of *N. felipei* on YouTube (2020; https://youtu.be/ucFl7dee1Ew, 2019; https://youtu.be/DW-s_V790v4, and https://youtu.be/pvy7bM8MfjQ), and additional videos of *N. frenata* were also provided (2020; https://youtu.be/9XI-9qgCI3M, 2019; https://youtu.be/Cpyu4vqcsWI).

Results

***Neogale felipei* (Izor & de la Torre, 1978)**
Figures 1, 2

New records. COLOMBIA – **Department of Antioquia** • Municipality of Jardín, Mesenia-Paramillo Natural Reserve, "Alto los Herrera"; 05°29′46.92″N, 075°55′04.44″W; 3013 m alt.; video (DSCF0025.AVI) • ibid.; 1 July 2019, 12:53 h; Elver Ledesma-Castañeda and Uriel Rendón-Jaramillo; video (DSCF0023.AVI) • ibid.;

Figure 2. Individuals of *Neogale felipei* and *N. frenata* detected at the Mesenia-Paramillo Natural Reserve, Cordillera Occidental of Colombia. **A–C.** Adult individuals of *N. felipei*. **D–F.** Adult and 0subadult individuals of *N. frenata*. Visible diagnostic characters are enclosed within the yellow squares. Photographs provided by Bioconservancy Foundation.

15 September 2020, 09:45 h; Juan Cepeda-Duque and Uriel Rendón-Jaramillo; video (Fig. 1B). • ibid.; "Predio El Desierto"; 05°29′11.54″N, 075°54′14.70″W; 2757 m alt.; 29 August 2019, 11:23 h; Elver Ledesma-Castañeda and Uriel Rendón-Jaramillo; video (DSCF0053.AVI; Fig. 1A).

Identification. Both *N. felipei* and *N. frenata* were detected in our survey. To avoid confusion, we highlight the diagnostic external characters that separate them as follows: *N. felipei* has a uniform blackish-brown face and dorsum, continuing consistently to the tip of the tail (Fig. 2A, B). The ventral coloration is orange-buff fading to whitish on the chin. The fur is relatively long, soft, and dense on the head and neck, gradually shortening posteriorly, forming a "tapered appearance" (Izor and de la Torre 1978). Two important diagnostic features of the species are the short, thick tail which lacks a black tip (the black tip is markedly visible in *N. frenata*; Izor and de la Torre 1978; Ramírez-Chaves and Mantilla-Meluk 2009) and a ventral patch or patches of about 15 mm long of the same coloration as the dorsum (not visible in the videos). The tail of *N. felipei* is about 46–57% of the head and body length ($n = 4$), whereas in *N. frenata* the tail is generally longer and can reach 70% of the head and body length (Sheffield and Thomas 1997).

Neogale frenata differs in coloration from *N. felipei* in several respects. First, the former has white facial marks, which are conspicuous in adults but fuzzy in young (Ramírez-Chaves and Mantilla-Meluk 2009). Second, *N. frenata* has a brighter brown dorsal coloration (Fig. 2e), a uniform ventral coloration without dark patches, and a long, slender tail (44–70% of the head and body length), with a distinctive black, tufted spot at its tip (Fig. 2D).

The sites where we detected both weasel species were characterized by having small trees <5 m in height, a closed canopy, and considerable litter cover and depth (Table 1). Sites also had moderate slopes with scant herbaceous and bare soil (Table 1). Activity of *N. felipei* peaked around the midday, followed by a decrease towards the early morning or late afternoon, with no evidence of activity at night.

Table 1. Habitat features measured at the two localities where *Neogale felipei* was detected during a long-term (2018–2021) trail camera survey at the Mesenia-Paramillo Natural Reserve, southern Antioquia, Cordillera Occidental, Colombia. Reported are the mean and standard deviation of the five measures taken at each trail camera station. See Methods for the data on each locality.

Habitat feature	Locality	
	Carlos Iván	Alto Las Herreras
Canopy height (m)	3.7 (1.94)	4.4 (1.48)
Canopy cover (%)	62.4 (29.48)	89.0 (10.93)
Foliage cover (%)	34.0 (41.64)	17.4 (18.13)
Litter cover (%)	50.2 (39.72)	82 (18.00)
Bare soil cover (%)	15.8 (34.22)	0.6 (1.74)
Slope (°)	12.6 (14.04)	16.6 (13.92)
Litter depth (cm)	14.0 (16.0)	27.7 (12.9)

Discussion

Our long-term trail camera monitoring in the cloud forests of the Mesenia-Paramillo Natural Reserve provided a chance to detect the rarest Neotropical carnivore, *Neogale felipei*. This finding extends the species' geographic range by approximately 120 km from prior records in the Cordillera Occidental of Colombia (Alberico 1994; de Roux et al. 2019). We suggest that information gaps in the distribution of *N. felipei* (the Wallacean shortfall) can have profound impacts on estimates of its conservation threat status. Our findings support the predictions of a recent study, which determined that there is a 37–58% chance of finding suitable environmental conditions for the species at the southern limits of Antioquia (de Roux et al. 2019).

Neogale felipei was regarded as a likely semi-aquatic carnivore given its pronounced inter-digital webbing (Izor and de la Torre 1978). Nonetheless, we agree with the observations of Alberico (1994), who suggested that such interdigital webbing may be more helpful in locomotion upon the highly saturated soils of cloud forests (Ramírez-Chaves and Patterson 2014). Our records suggest that sites with dense, deep litter cover are important for this predator to increase auditory perception and potential encounters with small mammals (Roche et al. 1999).

We documented the sympatric occurrence of *N. felipei* in an area where only *N. frenata* was previously reported (Bonilla-Sánchez et al. 2020). The sympatry of these two taxa in the Central and Occidental cordilleras had been suggested based on voucher specimen records (Ramírez-Chaves et al. 2012). In the Neotropics, little is known about the effects of interspecific interactions on sympatric weasels, although evidence from Nearctic weasels reveals that coexistence is possible through complex fitness and niche differences (Aunapuu and Oksanen 2003). If asymmetric competition is prevalent, larger weasels could displace and even predate upon smaller weasels (Rosenzweig 1966; Gamble 1980). Yet, coexistence is possible through other mechanisms, such as when the smaller weasels have access to prey not available or preferable for the larger ones (Wilson 1975), or when the smaller weasels are able to facultatively use less productive habitats and the large one relies on more productive habitats (Aunapuu and Oksanen 2003). Prey population fluctuations are key drivers for weasel coexistence, especially for large weasels, as they had greater energetic demands and lower reproductive rates than the smaller ones (Powell and Zielinski 1983; Aunapuu and Oksanen 2003). In Sierra Nevada, California, Ermine (*Mustela erminea* Linnaeus, 1758), which is smaller than *N. frenata*, specializes on underground voles and mice, whereas *N. frenata* consumes larger prey such as hares or rabbits on the forest surface (Fitzgerald 1977). The evidence of sympatric populations of *N. felipei* and *N. frenata* provided in this study offers a chance to prove if such complex interactions hold in the threatened tropical cloud forests.

Our data on the daily activity of *N. felipei* are unique (Hunter and Caro 2008). Despite having only three observations in the field, we speculate that there is a diurnal trend in the activity of this predator. Diurnal activity has been reported for weasels living in mesic environments, such as Common Weasel (*Mustela nivalis vulgaris* Erxleben, 1777), Altai Mountain Weasel (*M. altaica* Pallas, 1811), and Siberian Weasel (*M. sibirica* Pallas, 1773) (Jędrzejewski et al. 2000; Bishof et al. 2014; Zhao et al. 2019). Heat loss is pervasive in the slender and elongated bodies of these carnivores, given their large surface area to volume ratio (Sheffield and Thomas 1997). Thus, being active in the hottest hours of the day would be a common strategy employed to avoid heat loss while searching for food or mates (Bishof et al. 2014; Zhao et al. 2019). Besides that, more data is needed to support this inference on activity times of *N. felipei*.

Previous authors have emphasized the importance of direct research and management efforts on this threatened species within national parks and other publicly protected areas (Mesa-González 2006; Ramírez-Chaves and Mantilla-Meluk 2009; González-Maya et al. 2016). Here, we confirm that at least one population in the country falls within a privately protected area at the northern limit of its distribution. The Mesenia-Paramillo Nature Reserve has been previously recognized as a central core for the connectivity of unique assemblages of mammals, birds, and anurans in the Cordillera Occidental (Amézquita et al. 2013; Ocampo-Peñuela and Pimm 2014; Bonilla-Sánchez et al. 2020). This standing private reserve currently contributes to the connection between protected areas in the Cordillera Occidental, previously recognized as being important for the conservation of *N. felipei*, such as the Farallones National Natural Park (de Roux et al. 2019). Understanding which threats are important for the survival of *N. felipei* at the localities where it occurs is pivotal to focus management efforts and to prevent its vanishing in the near future.

Finally, camera traps have proven useful in monitoring elusive small carnivores, and new techniques such as the Mostela system (Mos and Hofmeester 2020) promises reliable new ecological knowledge on *N. felipei* and other elusive species. Complementing faunistic monitoring with citizen science (see de Roux et al. 2019) might further provide additional information on the rarest Andean carnivore.

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